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ABSTRACT

Analyzed is the energy management program implemented in 1984 at the Akron Public Schools of Ohio. The program was implemented to address the problems of rising utilities costs and uncontrollable energy use. Background information ranging from simple attendance statistics to the utilities budget are provided as well as the procedure for choosing an automation system and contractor. Reflected upon is the adequacy of the school district's specifications concerning the program and automation system operations. Costs have decreased with subsequent installations of newer technology. In comparing energy consumptions and costs each year, substantial reductions have been made in both natural gas and electric usage. The report shows the success of the program's original goals and reveals additional coincidental benefits. (SI)

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"ENERGY MANAGEMENT:

MAINTAINING A COST EFFECTIVE,

QUALITY ENVIRONMENT FOR LEARNING"

A CASE STUDY OF PROGRAM DEVELOPMENT AND OPERATION

By James R. Wiley,
Energy Program Manager

Akron Public Schools

Akron City School District

Akron, Ohio

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"ENERGY MANAGEMENT: MAINTAINING A COST EFFECTIVE,

QUALITY ENVIRONMENT FOR LEARNING"[1]

A CASE STUDY OF PROGRAM DEVELOPMENT AND OPERATION

By James R. Wiley, Energy Program Manager
Akron Public Schools

In 1984 Akron Schools began a new energy management program to address the problems of rising utilities costs and uncontrollable energy use. Reports and evaluations over the past five years have been very favorable, showing impressive success of original goals and revealing additional coincidental benefits.

While energy management programs and computer technology have been in use for many years before to our involvement, this program marked a significant step forward for our school district. We planned to create a program and a philosophy to make use of the newest technologies for energy management, paralleling a larger program for a district-wide approach bringing computer technology to all phases of education and administration in Akron schools. Thus "Operation Watershed" and our Energy Management Program were begun.

Such a program required much planning, research, and investigation. Indeed, there had been nothing like it in Akron Schools, nor anything like what we planned in any other school district, giving no precedents to follow. Now, five years later, we are able to assess the appropriateness of the original goals and the wisdom building in flexibility for the program to meet the goals. Our objectives in presenting our proposals were included in a simple visual aid that clearly stated our goals:

An Energy Management System

Objective: **To reduce energy waste**

How: by operating mechanical equipment - - -

- Only when it is needed

- At its peak efficiency

- To match environmental conditions

1. Excerpted from a presentation at the 1988 annual convention of the Association of School Business Officials for the U.S. Department of Energy, Region 5, Detroit, October, 1988.

BACKGROUND:

Akron City School District is the fifth largest in Ohio with 33,300 students, 59 school buildings, and a staff size of over 4,400 full and part-time employees. We have eight high schools, nine middle schools, 42 elementary schools and a dozen auxiliary and administrative buildings, comprising over 5 million square feet of building space. We have approximately 180 maintenance employees in six different shops for electrical, plumbing, carpentry, painting, audio-visual and hardware maintenance and approximately 225 full-time custodial employees who operate the schools' heating, ventilating, and air conditioning equipment. In 1982 our utilities bills budget was $5 million annually and rising rapidly.

Our school buildings range in age from a century old to structures built just this year. Like many communities in the midwest, Akron experienced periods of rapid growth during which most of our facilities were built. Except for schools built most recently to address needs for modernization and shifting population patterns, most of our schools were built in the periods of 1910 to 1930 and the baby boom years of the 1950's. Over the years we converted many schools from coal and oil burning boilers to natural gas, with air conditioning added here and there as educational programs dictated and as facilities expanded in the sixties and seventies.

The "Oil Embargo" energy crises of the 1973 brought home the realization of our inability to control adequately our energy use. We recognized the implications of operating schools that are decades old with failing or unreliable heating, ventilating, and air conditioning systems and controls. In years past when schools were built without much attention to energy consciousness, the primary duty of maintenance and operations had become to " ... keep the schools' open ... " with little regard for energy conservation. While we never closed a school due to HVAC equipment failures, we realized we needed a major change of direction in our approach to using energy.

A major impetus for this change came from participation in the Federal government's energy grants program in the late 1970's and early 1980's, the "National Energy Conservation Policy Act," or N.E.C.P.A. Through this program, we were able to begin to amass a database of information about our schools and our energy use patterns that became a basis for planning a comprehensive approach to energy management. We identified easily recognizable "quick fix" measures that could be readily undertaken, such as weather stripping, insulation, etc., but the larger picture was of a large city school district needing a more controllable management approach to energy use.

We determined to create a new program with a new department, to establish a new approach to provide responsible energy use, a comprehensive approach to preventive maintenance, consistent operations practices, and to maintain the best environment for learning in our schools that we could provide. We needed to combine elements of financial planning and evaluation, maintenance, construction, and HVAC systems operation in one department.

Our proposals recommended an energy management office under our School Architect's office (the equivalent of other districts' "director of physical plant") to coordinate energy management implementation with our maintenance and custodial departments. Responsibilities for HVAC equipment, controls, and operations were split between these two departments, and to some extent continue to be so, creating inconsistency in equipment maintenance and operations.

By job descriptions and contract language certain maintenance tasks were restricted to the maintenance department, and similarly, maintenance workers had no control over how equipment was operated and maintained on a daily basis by building custodians.

Our studies and audits also showed that the practices and patterns of equipment operation varied widely from school to school. While building principals and custodians may have the best intentions, they lack the perspective of a district-wide approach to energy conservation.

There were two key elements to our approach to a formal energy management program: to repair, recalibrate, and maintain all existing controls for maximum efficiency, and, the most attention getting, to install a district wide computer based building automation system to monitor and operate major HVAC equipment in all schools.

Our plans for the energy management program included that the new department assume responsibility for HVAC controls maintenance and for equipment operations through the building automation system. We also included responsibility for operating, maintaining, and programming the automation system. A typical program of retrofit and implementation of the automation system for a school includes a complete evaluation of the school's HVAC equipment and controls systems for identification of needed repairs, evaluations of the school's unique operational and occupancy patterns, replacement of broken or missing control elements, and complete recalibration of existing pneumatic controls before installation of the new automation system.

These plans were based on studies and technical audits performed under the NECPA grants program which revealed, generally, that we had many broken, missing, or out-of-calibration controls. For years our maintenance department had performed minor miracles keeping equipment operating and keeping schools open, based on a "band-aid and bailing wire" repair strategy when funds and schedules did not provide for a comprehensive preventive maintenance program.

CHOOSING AN AUTOMATION SYSTEM AND CONTRACTOR:

For our program development the chief question became, "Which automation system would best fit our needs?" In 1982 and 1983, during the planning stages of our program, there were dozens of major and lesser automation manufacturers, installers, service contract operators, and as many schemes for paying for it ranging from lease-purchase, shared savings, and non-ownership, non-operation installations.

There were large established companies with excellent reputations, and there were automation companies establishing themselves almost overnight (and sometimes disappearing as quickly).

We worked closely with our consulting engineers, Keyser Engineering Inc., who had conducted our grants application "Technical Audit" activities and therefore knew our buildings, systems, and problems very well. We conducted extensive investigations of automation systems capabilities, compared them with our needs, and developed a strategy for planning a performance based specification for an automation system. We visited installations of all the major manufacturers, interviewed the operators and "residents" using the systems, and we gathered information to create a schedule of priorities for a system of our own.

Having determined what we wanted from an automation system we still were faced with two major areas of concern. The first was how to determine which company, from among the proprietary languages and differing system architectures, best met our requirements for flexibility, non-obsolescence, and that buzz word "user friendliness." The second concern was, related to non-obsolescence, how to assure manufacturer and installer support.

Since we planned an installation over a five year period for all schools we had concerns that the manufacturer should continue to support the system. We hoped to continue to expand that system rather than find ourselves abandoned after heavy initial investments, possibly ending with several separate, incompatible systems.

From the engineering and maintenance standpoint we felt that the best of the systems available was a type that used independent remote micro processors for each school, and for each major HVAC equipment room within a school. We wanted assurances of system integrity in the event of power or communications loss at the central console, or at any link within a school. We wanted remote control panels within the schools to be as close as possible to the equipment being monitored and controlled for purposes of equipment checkout. We wanted technicians to be able to connect to any control panel within a school and be able to access equipment in that or any other area.

There were also important considerations for communications: we wanted a communications system between the central computer and the remote sites that used the most reliable and the least costly communications system available, if not radio transmission, then ordinary business telephone lines as compared to leased line strategies.

In our bid specifications we incorporated "benchmark" standards to address these concerns and to establish, before bidding, the standards for evaluation of bid submittals. We specified control parameters and strategies that were required, the type of system architecture required, and installation requirements. To guarantee pricing of major components to be purchased in subsequent years we required a

unit cost pricing structure based on inflation related to a Federal price index for electronic HVAC controls elements.

Finally, as a method to assure installer and manufacturer support for five years, we required that the bidder must be a manufacturer and installer of the equipment, and that the company be of a certain substantial net worth. Since potential bidders were looking at a program that would cost as much as $4.8 million over five years (including existing control systems modifications, sensor installation and wiring, engineering design, etc.) there was much interest in this bid and a great deal of discussion of the bidder requirements. On our part, we were very concerned about industry reports of companies going out of business, dropping product lines and systems, and about getting experienced quality mechanics for installation and start up of the main system.

In June of 1984 we received three bids for the project from major system manufacturers who could meet the installer/manufacturer and net worth requirements. An extensive process of evaluation of the bid submittals provided a recommendation for award of contract, and also provided further evidence of the variety and complexity of the various systems. After a lawsuit over the contract award by two of the bidders, in which our specification requirements and bid evaluations were held to be valid and appropriate, we proceeded with the installation of the first phase of our system.

PROGRAM AND AUTOMATION SYSTEM OPERATIONS

Five years later we can reflect on the adequacy of our specifications. Two bidders are no longer supporting nor installing the systems which they were bidding in 1984. Most of the other systems offered in 1984 that could meet most of the performance requirements have either undergone major changes (not supporting original equipment) or have been bought out or have gone out of business. Most of the contract, franchisee, or other non-manufacturer installers are no longer with us, at least not with the same systems which they had in 1984. More importantly, we still are developing the same system with which we began, with successive upgrades and enhancements by the manufacturer.

Now there are automation systems in 51 of our schools, with the eight smallest to be completed this year. System size has grown to over 6,000 control and monitor elements or "points" in nearly 300 remote control panels. We have buildings with as many as 400 points and others with as few as forty. Our largest high school has sixteen control panels and the smaller elementary schools get by with a single panel.

There have been changes and unforeseen experiences in our program. Meeting our goals required frequent evaluation and shifting of priorities. For the first couple of years of the program we spent more than was planned for necessary retrofit and recalibration of

pneumatic controls, using funds that were allocated for automation system expansion.

To offset some of the additional costs of those contracted services and non-warranty repairs we shifted gears early in the program to begin automating the largest schools first. We also continued to include smaller elementary schools and completed the last secondary school this year. Last fall's annual report and evaluation still showed, however, a faster rate of payback than originally anticipated due partly to this approach change. We are slightly ahead of schedule on paybacks despite early heavy initial investment and lower than anticipated natural gas rates.

Other unexpected experiences included the intensity of reactions to the automation system. While we tried to portray our plans and expectations realistically there were many who were skeptical of the automation system's ability to function as planned. Resistance to this new element of control seemed to be based on a natural intimidation of people unfamiliar with computer screens and keyboards. We always placed a heavier importance on equipment operators having a good working knowledge of HVAC systems, not computers, and of a school's unique operating conditions and environment. Even in creating a new job description for controls maintenance workers we emphasized a strong background in HVAC controls rather than any computer experience.

Most custodians, all of whom have been provided a CRT screen and keyboard to access their schools' systems, have adapted so well to their new equipment that they rely on it heavily for monitoring and operating their HVAC equipment. Many custodians have made very helpful suggestions for improving operations from scheduling changes to more detailed analyses of electrical peak demand causes. Requests are nearly always for expansions of capabilities. Requests for increasing our training program for the automation system are taxing our ability to keep up with training schedules.

Among early rumors that circulated was that the automation system would be used to replace custodians. Rumors were that there would be layoffs and a loss of overtime. While there have been no layoff's, we have certainly reduced the amount of overtime needed for controls repairs. We felt that there is a necessary relationship of automation system to pneumatic controls requiring a joint responsibility for computer related controls with existing pneumatics. A new job description for "HVAC Controls Technician" still causes difficulties with contract language interpretations regarding responsibility for certain repairs, and what constitutes "controls" in the HVAC system.

Custodians have access to all equipment operated or monitored with the system. They are provided with customized control points which they can command via their own CRT/keyboards to reset operating limits, discharge air temperatures, start and stop times, damper positions, and any other function of the system. Instead of being removed from the control process, custodians are able to use their systems to watch for clogged air filters, malfunctioning fans and pumps, critical temperatures, and sometimes they can watch for rising temperatures in cafeteria food coolers and freezers to avoid costly losses there.

Custodians find more information immediately available in the morning with their CRT screens than they can get by walking the building for an hour. Some have complained that the system can be a nag, reminding them of problems needing their attention.

After hours activities at the schools requiring HVAC services are handled in a variety of ways. Custodians can pre-program fans on and off for an evening activity and can program selected areas to operate alone without running all equipment via "zone" scheduling. Some of the more experienced, motivated operators have become quite proficient and creative at customizing their building's operations.

Most of these capabilities were among the fairly standard original control programs. After initial installation contracts, and after hiring our own HVAC Controls Technicians, we have expanded and refined our control capabilities with our own forces. Problem areas' old pneumatic controls, which require frequent and regular recalibration and adjustment, are increasingly replaced with direct digital control through the automation system. By doing our own data entry, programming, and start-ups, and by taking advantage of newer technology (at lower cost) in the automation system components, our costs per point have decreased with subsequent installations.

PROVIDING THE PROPER ENVIRONMENT FOR LEARNING

In the first winter of its operation there were 12 schools functioning on the automation system. By January, 1986 the number of schools had doubled. There was no full time operator of the automation system, and no full time monitor watching for alarm conditions. Because of concern for building freeze-up's and being sensitive to the program and the system reputations, there were many nights and early mornings when frequent checks were made on conditions in these schools. (Remote access to the entire system or any school is possible with ordinary personal computers and telephone modems.)

There were no freeze-ups of equipment being operated or monitored by the system. We had no school closures due to equipment failure. We were able to provide wider and more frequent monitoring via the system, augmenting custodians' overtime to preheat schools on Monday mornings and on very cold weekends. In some instances we were able to anticipate potential problems and provide warnings before any damages could occur.

After two successful winters the system integrity was of less concern. That and the quickly increasing numbers of schools automated made it more than a simple job of a few hours here and there to check situations on a cold weekend. We still have no full time system monitors, however, in our present mode of operations this is not a concern.

Calculating the value of unpredictable equipment failures which are prevented through timely maintenance is impossible. Maintenance

directors and workers can appreciate the value of preventive maintenance as compared to trying to repair a broken piece of essential equipment, assuming parts might be found, and if they can be readily obtained at a reasonable cost. According to one of "Murphy's Laws" these things always occur at the worst possible moment, and the perceptiveness of hindsight always says, "We should have replaced this last summer!"

Decreasing utilities consumption however has provided a method to assess the program's success. Our savings to date in the program have reached over $2 1/2 million. By comparing energy consumptions and costs each year, on a school-by-school basis, against a pre-automation base year we have made substantial reductions in both natural gas and electric usage. These are dollars that now can be spent on educational purposes.

Funding energy management operations on a basis of savings generated, even when adequately documented, has some pitfalls, however. There are so many uncontrollable aspects to consider including weather patterns, (of warmer than expected winters) utility rate increases, rate structures changes, and unpredictable equipment failure and replacement costs. All these can cloud the picture of what the real savings of such a program are.

Akron schools recently passed a levy for a general operating fund increase that was our first in fifteen years. Needing increases in staff sizes to continue to meet and exceed State requirements, (in the face of decreasing state funding for education) and meeting the rising costs of other goods and services needed to operate a large city school district required a 6.5 mill increase in our locally voted millage. One significant fact which may have helped pass that levy was that our fixed costs for utilities was showing a substantial decline. We were able to provide information that showed utilities as a part of our fixed costs decreasing at a rate of 28% to 32% since 1984, despite increasing utility rates.

There is also evidence that we have improved the environmental conditions in many classrooms in our program of repair, retrofit, calibration, and automation. Even though HVAC problems do occur some teachers have expressed thanks for correcting long standing problems in their rooms. Most successes go unnoticed, however, because a successful program prevents problems more than it corrects them.

With old mechanical control devices one must expect problems. Most problems however are often situations that can shorten the learning curve in customizing programs and operations schedules. Some problem types are unavoidable. Bringing a school on-line with the automation system always requires a certain amount of "debugging" time, or time to refine standard or stock programming procedures. A school which goes on-line in summer can't have its heating equipment fully checked out until later in the fall. Neither is the middle of winter the best time to try to debug equipment, when getting enough heat to every corner of a school is a primary concern. Our position is that there is no "average" or "typical" school, and making a controls system work for a particular school sometimes requires patience

and understanding on everyone's part.

In other instances there have been control procedures from which we have had to back off or modify when they were found to be causing problems. "Duty cycling" equipment, or shutting down equipment for a portion of each hour, for example has been less than totally successful. There is a psychological factor involved in hearing a fan shut down in a room that already feels stuffy. Standards set by governmental or engineering agencies for ventilation have had to be regarded as minimum recommendations which often may not reflect actual conditions in a real school setting. Vocational education labs, for example, may require more ventilation or heating than may be required for a similar industrial application. Savings projected on a basis of marginally applicable standards will need modification.

Another example of offsetting conditions involved ventilation of rest rooms. Older school buildings typically are not designed for extensive toilet room ventilation. For this reason we are still modifying ventilation schedules and duty cycling schedules for these areas. When considering the savings of duty cycling these smaller motors and the problems this can cause, it has been decided that this is not an advantageous use of an automation system. Motor life itself is shortened by duty cycling, and recognizing this, it is probably a better planning technique to expect to reinvest some of the savings in motor replacement and newer technology's "soft start" devices.

Being in an area of new technology with little precedent can create unforeseen problems with regulatory agencies also. Ohio has a somewhat unique code for steam boiler operations in that boilers which are more than 30 horsepower require a licensed operator to be present and in direct charge of the boilers at all times. Local licensing inspectors have variously interpreted this to mean that an automation system may not be connected to these boilers, to more recent interpretations permitting automation systems which do not remove these boilers' control from the on site licensed operator. Like some contract language, job descriptions, and other pre-automation standards, regulatory standards are often decades behind the current technology, requiring tedious work to establish legitimacy for a technology that is commonplace in science and industry.

Our best successes have come from extensive planning, in depth assessment of equipment and conditions, and in providing flexibility in the program and automation system. Undertaking a school district's own engineering and design, contract management, and system operation and maintenance provides the best assurance of quality and integrity of the entire process of installation and operation.

A story which some years ago made its rounds locally, probably apocryphal and widespread now, is of a customer who made an expensive purchase of a "black box" device to cut his utility bills. What he got was a one-time repair of broken or uncalibrated controls. A new consultant discovered, after the original installer's service contract had expired, that the mostly empty, largely non-functional box of electronics apparently was no more a simple time clock. Reliance on vendors for planning and engineering can lead to problems beyond con-

flict of interest.

Evaluating present HVAC equipment and controls for proposing retrofits and repairs should include making inquiries of the equipments' operators as to operational problems and suggestions. Building custodians often can provide a history of repair needs and improvements ideas if consulted. Our advantages of gaining support at the building level are most successful when custodians have had input to the system design, rather than feeling it was impulsively inflicted on them.

Even when detailed planning and research are successful they tend to produce their problems of coping with the bulk of information relating to those activities. With the volume of utility bills' data collected, and the information needed for planning schools' automation we have amassed a sizable amount of data never collected in one area before. The scope and sequence of the NECPA grants program has provided a basis for acquiring detailed information on all our buildings. Only with the use of personal computers have we been able to manage our expanding data base.

Our next five years will be a more limited program of expansion and refinement of our system. We expect to include the remainder of our buildings, the administrative and auxiliary buildings, in our program of automation. Having attained our full complement of four "HVAC Controls Technicians" will permit better preventive maintenance schedules and more detailed automation system refinements. The past five years' experience will provide a basis for planning for the next five years.

Planning on a five year schedule for energy management parallels the funding method used to pay for all capital improvements in Akron Schools. We have provided all new buildings, all remodeling and renovation projects, and all energy management projects from a continuing five year special "Building Improvements Levy" that has been approved by our voters for thirty-five years! Funds allocated for energy management projects have been augmented by grants under the NECPA program and Ohio's "Institutional Conservation Projects" matching grants program. Since creating an energy management office, permitting a more committed effort to making more extensive and comprehensive activities including grants applications, Akron Schools have received $350,000 in matching grants to help complete the automation system and to fund other energy conservation construction projects.

Our enviable financial position for being able to fund such projects comes from responsible management of a levy campaign every five years which has had as its motto: "...Pay as you go..." as compared to bonded indebtedness. Astute treasurers over the years have actually earned interest on our funds, as compared to paying it for loans. Our current millage of this levy raises approximately $4.26 million annually. District wide needs assessments, being conducted now, will very likely identify three to four times the number of projects that the approximately $22 million five year levy can fund.

For our part in energy management we expect to undertake fewer

installation projects and concentrate on expanding, refining, and maintaining our existing program and automation system. A larger share of our operating costs will now be coming from our general operating fund, based on evaluations of performance of the program. Annual reports to our Board will continue to show the wisdom of implementing this program, both in dollars and cents, and in providing a manageable response to the past and coming energy crises.

Although the Federal government is going out of the energy conservation grants "business" and Exxon rebate funds are rapid'y dwindling in most states, other funding methods with reasonable pay backs are still very attractive for saving on utilities, gaining control of energy use, and providing a vehicle for a preventive maintenance program for HVAC controls.